# DOUBLE POLARIZED NEUTRON FORM FACTOR MEASUREMENT AT HIGH $Q^2$ VIA $^3\vec{\mathrm{H}}\mathrm{e}(\vec{e},e'n)$ WITH THE SPECTROMETER FACILITY AT THE MAINZ MICROTRON

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A new approach to determine the neutron electric form factor $G_{en}$ at high momentum transfer ($Q^2 = 0.7(GeV/c)^2$) is presented by the A1-collaboration at the Mainz Microtron MAMI. Due to the small value of $G_{en}$ compared to $G_{mn}$ a favourable procedure is to measure an asymmetry in the exclusive quasi elastic scattering $^3\vec{H}e(\vec{e}$,e'n). The polarized $^3\vec{H}e$ nucleus serves as a polarized neutron target. A high resolution magnetic spectrometer ($\Delta E/E = 10^{-4}$) is used to distinguish between quasi elastic and inelastic processes ($\Delta$-resonance and $\pi$-production ) by the scattered electrons. The neutrons are detected in a segmented plastic scintillator with a detection efficiency of 30%. A guiding field permits the rotation of the target spin in the desired direction, especially perpendicular and parallel with respect to $\vec{q}$. The ratio of the asymmetries $A_\perp/A_\parallel$ is taken, which in first order depends only on kinematical factors and the ratio $G_{en}/G_{mn}$. A monitoring reaction for the product of electron and target polarization is provided by the simultaneous measurement of elastic $^3\vec{H}e(\vec{e},e')$ scattering.

## 1 The experiment at A1 collaboration

### *1.1 Detector Set-up*

The nucleon detector [1] covers a solid angle of 100 msr. It consists of 9 scintillator bars (50 x 10 x 1 cm$^3$) used as $\Delta E$-detectors with 20 E-detectors (50 x 10 x 10 cm$^3$) behind it. Protons and neutrons are detected simultaneously. Two photomultipliers face each scintillator bar in order to reconstruct the vertical coordinate by TOF difference. Towards the target the neutron detector is shielded by 2 cm of lead. Due to very efficient lead shielding around the target region and the neutron detector itself, background rates are about 50 - 100 kHz in the $\Delta E$-detectors and less than 5 kHz in the E-detectors at a current of 10 $\mu A$ and suitable trigger thresholds. The scattered electrons are detected in coincidence with the nucleon by spectrometer A [2] of the A1-collaboration at MAMI within a solid angle of 28 msr fixing the momentum, the azimuthal and the polar angles of the outgoing electrons. A gas Cerenkov-detector inside the spectrometer suppresses pions. Spectrometer B with a solid angle of 5.6 msr serves to determine the polarization product $P_e * P_{He}$ via elastic scattering $^3\vec{H}e(\vec{e},e')$. Similar to the quasi elastic asymmetry an elastic asymmetry is measured which contains the elastic form factors of the $^3He$-nucleus. These form factors are known to better than 2% [3]. Due to the large elastic cross section a statistical accuracy of 5% can be reached in 1 h, using a current of $I = 10\ \mu$A, an electron polarization of $P_e = 0.7$, a $^3$He polarization of $P_{He} = 0.4$ and a target pressure of 6 bar.

### *1.2 Target Set-up*

The $^3He$-gas is polarized by metastable optical pumping[4] at 1 mbar pressure. Subsequent polarization preserving compression to 6 bar is achieved with a two stage titanium piston compressor[5]. In the pilot run, target cells were filled with 6 bar $^3\vec{He}$ plus 6 mbar $N_2$ to suppress the formation of strongly depolarizing $^3He_2^+$ ions. Filled target cells are transported to the target place in a Helmholtz field. By changing the target twice a day an average polarization of 32 % was obtained. The relative gradients of the magnetic guiding field for the polarized target should be less than $1 * 10^{-3}$ cm$^{-1}$ to prevent longitudinal relaxation and to enable polarization measurement by NMR and AFP. Due to the stray field of the magnetic spectrometer with a gradient of $1.5 * 10^{-2}$ cm$^{-1}$ and a magnetic field of $B_o = 2$ G, the guiding field (4 G) is produced within a $\mu$-metal shielded box by 3 independent pairs of coils. This construction enables us to rotate the target spin in any direction and permits the measurement of $A_\perp$ and $A_\|$, where the spin direction is perpendicular and parallel with respect to $\vec{q}$. After usage the cell is reconnected to the polarizing system to recycle the depolarized $^3He$.

### *1.3 Preliminary results*

In the pilot run in summer 97 the collected charge on target was 384 $\mu$Ah. The electron source used a strained layer GaAsP crystal yielding 70 % polarization and a current of up to 10 $\mu A$. The electron spin was flipped statistically with 1 Hz. The initial polarization of the $^3He$-target was between 42 and 47 % (measured by AFP) with relaxation times of 20 - 32 h. Since two directions of the target spin were used, one can extract $G_{en}$ from the ratio $\frac{A_\perp}{A_\|} = \frac{a}{b}\frac{G_e}{G_m}$ (a,b: kinematical factors) which is in first order independent of the polarization product $P_e P_{He}$. Several corrections determined by Monte-Carlo simulation are used to extract $G_{en}$. Basically these are the momentum acceptance of the spectrometer, energy losses due to bremsstrahlung as well as 'missing energy'[6]. Considering these corrections and using a dipole fit for the magnetic form factor, one obtains an electric form factor of the neutron:

$$G_{en}[Q^2 = 0.667(GeV/c)^2] = 0.050 \pm 21.7\% \pm 4.3\%.$$

A new measured $G_{mn}$ value of Anklin[7] deviates from the dipole value. This would give rise to a shift of $G_{en}$ to 0.052. The statistical error will be further reduced in future measurements.

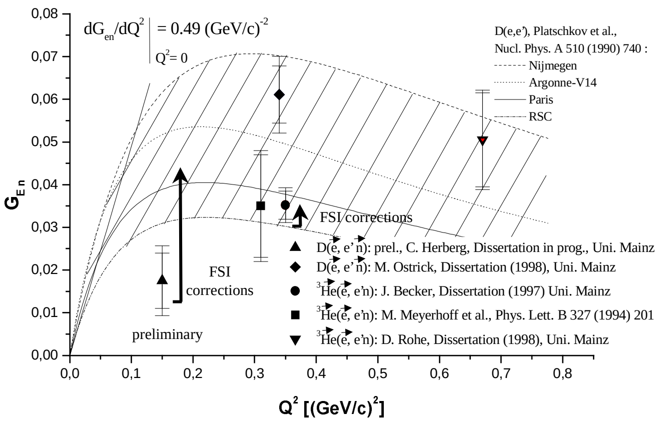


Figure 1: Recent $G_{en}$ measurements at Mainz. Statistical and total errorbars are shown.

## 2 Discussion of recent $G_{en}$ measurements at Mainz

The present result is shown in fig.1 together with all previous data obtained by the A3-collaboration at MAMI. The curves show the fitted data of Platchkov et al. with respect to several nucleon-nucleon potentials. The obvious discrepancy between the measurements in the $D(\vec{e}, e'\vec{n})$ and ${}^3\vec{H}e(\vec{e}, e'n)$ reaction at $Q^2$=0.35 $(\mathrm{GeV/c})^2$ will be only partly reduced by FSI (final state interaction) corrections as Gloeckle and Ziemer (priv. commun.) calculated for the ${}^3He$ data (indicated by the arrow). If meson exchange currents (MEC) and relativistic effects are included the correction factor may increase. Moreover there may be medium effects which will affect the fundamental form factors differently in D and $^3$He. The rigorous FSI calculations by Arenhoevel (priv. commun.) shifts the deuterium $G_{en}$ measurement at $Q^2 = 0.14(GeV/c)^2$ by a large amount. Other corrections like MEC, relativistic corrections and isobar configuration currents (IC) are negligible. At $Q^2$=0.34 $(\mathrm{GeV/c})^2$ the FSI corrections can be already neglected in case of deuterium [8].

## References


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